

Cross Sections for ν_τ N

Cross sections have been computed for tau-neutrino reaction on nucleons using expressions for the differential rates up to $O(m^2/E^2)$. These expressions were integrated over the variables x_{Bj} and y to yield the total cross sections, $\sigma(\nu N)$. This includes the kinematical effect of the large lepton mass which suppresses the interactions at low E_ν , with an effective cut-off at 5 GeV. The computations were made with one set of structure functions and assume they are valid over the whole range of the variables. Thus only DIS is assumed and the additional contributions from “quasi-elastic” processes are not included. Also perfect strong-isopin symmetry is assumed, i.e. the quark distributions of the nucleons obey: $u_n(x) = d_p(x)$ and $u_p(x) = d_n(x)$.

The differential cross section, $d\sigma/dydx$, for production of heavy leptons was taken from a paper of Albright and Jarlskog¹. The structure functions F_2 and F_3 used are the ELHQ set². The integration of the differential form was carried out over the entire kinematically allowed region in the (x,y) plane. The Callan-Gross relation, $2xF_1=F_2$, was used explicitly. The computation was done using the Maple V mathematics software. The final form for σ/E was a functional fit to the computed points at 10 values of E of the form:

$$r(E) \equiv \frac{\sigma(\nu_\tau)}{\sigma(\nu_\mu)} = C_1 - \left[\exp\{-C_2(E - E_0)\} \right] (C_3 + C_4E + C_5E^2).$$

Table 1 shows the values of the integrals and the ratios, r , for the neutrino and anti-neutrino cross sections. Using the same structure functions, the values for the ν_μ cross sections of an isoscalar target are $\sigma(\nu_\mu)/E = 0.634 \times 10^{-38} \text{ cm}^2$ and $\sigma(\bar{\nu}_\mu)/E = 0.315 \times 10^{-38} \text{ cm}^2$ at $E = 100 \text{ GeV}$. Table 2 gives the values of the fitted constants for the kinematic factor r . Neglecting the difference between the mass of the proton and the mass of the neutron, the ratio of the cross sections, $R = \sigma(\nu n) / \sigma(\nu p)$, is computed to be 2.4. If N_p and N_n are the number of protons and neutrons in the nuclear target, then the enhancement for neutrino interactions compared to an isoscalar target ($N_p = N_n$) is

$$\frac{\sigma(nucleus)}{\sigma(N)} = \frac{2}{R+1} \cdot \frac{N_p + RN_n}{N_p + N_n}.$$

For anti-neutrino interactions, interchange n and p indices. For emulsion, with an equivalent of $N_n=15$ and $N_p=12$, the $\nu(nucleus)$ increase is about 4%. The total ν_τ cross section is result of the above multiplicative factors,

$$\sigma(\nu_\tau) = \left(\frac{\sigma(\nu_\mu)}{E} \right) \cdot r(E) \cdot \Delta_n(A, Z) \cdot E$$

E (GeV)	$\sigma(\bar{\nu}N)/E$	$\sigma(\nu N)/E$	$\sigma(\nu_\tau)/\sigma(\nu_\mu)$	$\sigma(\bar{\nu}_\tau)/\sigma(\bar{\nu}_\mu)$	$\sigma(\bar{\nu}p)/\sigma(\nu p)$
6	0.0057	0.0110	0.0290	0.0279	0.517
8	0.0135	0.0297	0.0688	0.0750	0.455
10	0.0219	0.0502	0.1116	0.1267	0.438
15	0.0413	0.0967	0.2099	0.2441	0.427
25	0.0695	0.1621	0.3533	0.4091	0.429
50	0.1070	0.2425	0.5436	0.6122	0.441
75	0.1260	0.2800	0.6402	0.7069	0.450
100	0.1378	0.3020	0.7002	0.7623	0.456
150	0.1519	0.3269	0.7722	0.8253	0.465
300	0.1700	0.3562	0.8642	0.8991	0.477

Table 1. The values for the cross sections are to be multiplied by $G^2 m_p / \pi$ ($1.6 \times 10^{-38} \text{ cm}^2 \text{ GeV}$) to convert to standard units.

	$r(\nu p)$	$r(\bar{\nu} p)$
E_0	2.5174	2.5922
C_1	0.87490	0.90485
C_2	0.02337	0.02581
C_3	0.95292	1.0112
C_4	-0.006116	-0.009087
C_5	0.000139	0.000169

Table 2. The values of the parameters used in the above function to approximate the value of r .

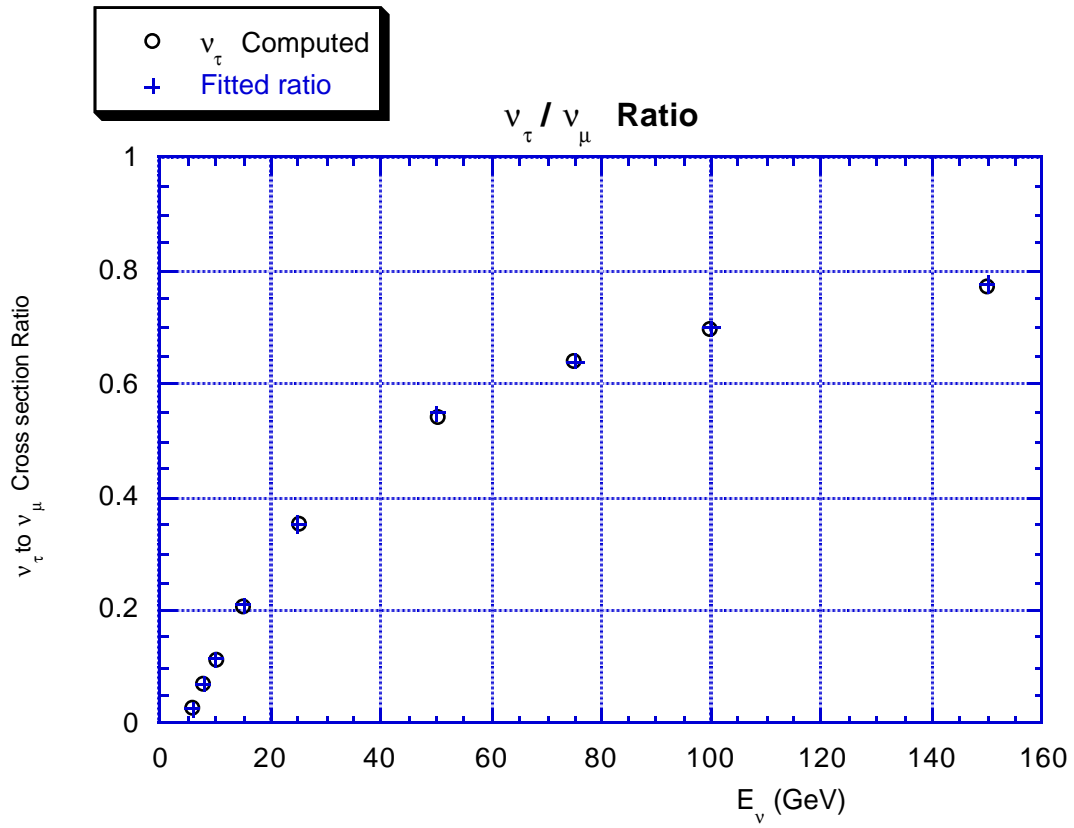


Figure 1. Graph of r for the νp process, comparing the computed points with the values obtained from the functional fit.

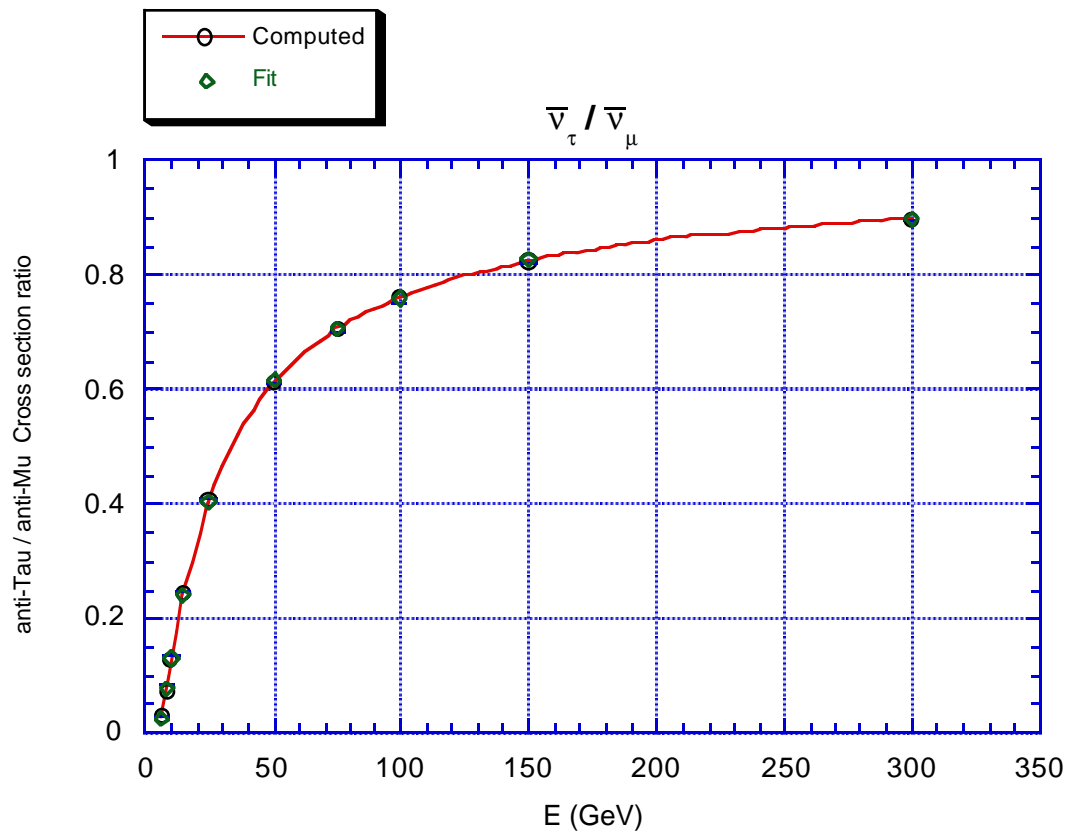


Figure 2. Graph of r for the $\bar{\nu}p$ process, comparing the computed points with the values obtained from the functional fit.

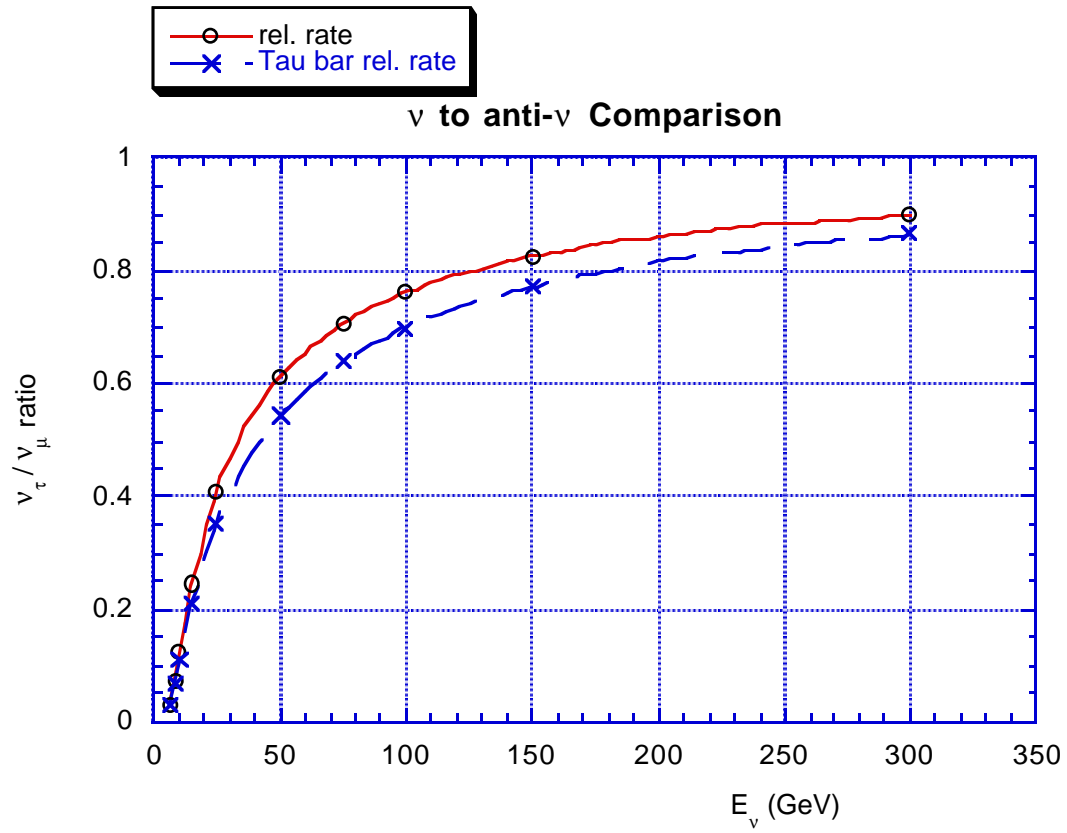


Figure 3. Graph comparing the values of r for the neutrino and anti-neutrino data.

¹ C.H.Albright, C.Jarlskog Nucl. Phys. **B84** 467 (1975).

² E. Eichten *et al* Supercollider Physics, Rev. Mod. Phys. **56** 579 (1984) ; erratum **58** 1065.